SYNTHETIC BIOLOGY DEPARTMENT
AT BERKELEY LAB

In July 2003, the Physical Biosciences Division at Lawrence Berkeley National Laboratory established the world's first Synthetic Biology Department, which seeks to understand and design biological systems and their components to address a host of problems that cannot be solved using naturally-occurring entities. Employing organisms and biologically inspired systems to solve real-world problems has enormous potential for human health, renewable energy, and the environment. Synthetic biology also provides an alternative perspective from which to consider, analyze, and ultimately understand our living world.

- **Cheap, environmentally responsible production of medicine from microbes**

A chemical pathway in *Artemsisia annua* produces the anti-malaria drug artemisinin

1.5-2.7 million people die of malaria every year, and 90% of the victims are children. Although the plant-derived drug artemisinin has a near-100% success rate in treating all known strains of malaria, it's still too costly in developing countries, where malaria is growing resistant to affordable treatments. By inserting genes from three separate organisms into *E. coli*, synthetic biologists have created a bacterial strain that can produce the precursor to artemisinin. It's the first step toward mass-producing a cheap and effective solution to malaria in developing countries. Synthetic biologists hope to use this same technique to mimic a chemical pathway found in the medicinal Mamala tree of the Philippines to develop a drug that fights HIV. By combining genes to create chemical factories within microbes, synthetic biologists can produce new drugs to fight disease, combat bioterror agents, and produce existing drugs without depleting our natural resources.

- **Conversion of plentiful, renewable resources into energy**

Our planet produces over 100 gigatons of biomass every year, much of which is in the form of cellulose. Almost all of the earth's cellulose is broken down by enzymes in organisms and converted back into minerals. But that cellulose could become a source of renewal energy if synthetic biologists could use the molecular machinery in microorganisms to efficiently capture the energy stored in cellulose. One strategy is to insert the cellulose-converting proteins into robust, benign microorganisms such as *Bacillus subtilis*. Such approaches could lead to microorganisms that produce hydrogen or efficiently convert sunlight energy into other chemical forms. Taking inspiration from biology, synthetic biologists will eventually understand how to design efficient, robust energy-producing systems from scratch, then build them.

Why do we need synthetic biology?

Energy production
- Production of hydrogen or ethanol
- Efficient conversion of waste into energy
- Conversion of sunlight into hydrogen

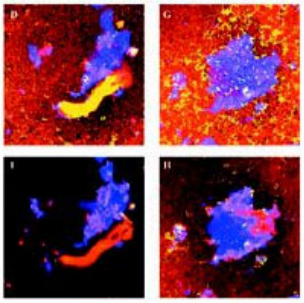
New materials
- "Soft" biomaterials for tissue/organ growth & drug delivery
- "Hard" biomaterials for micro/nano-fabrication processes, microelectronics, membranes, and catalytic surfaces

Chemical/biological threat detection and decontamination
- New cells that will swim to the threat and decontaminate it

(continued)

- **Bioremediation: A natural solution to environmental contamination**

To take advantage of natural biodegradative pathways in certain microorganisms, synthetic biologists are studying the metabolism and genetic control systems of microorganisms that help neutralize a number of important environmental contaminants. In addition, they are engineering microorganisms to remediate some of the most potent environmental contaminants, including heavy metals, actinides, and nerve agents. Such organisms have enormous potential for decontaminating hazardous waste spills and treating byproducts from the nation's nuclear energy and disposal sites.



Berkeley West Biocenter: A home for synthetic biology

Berkeley Lab and UC Berkeley have joined forces to establish the Berkeley West Biocenter, a multidisciplinary research facility in synthetic biology, cell and molecular biology, cancer research, and quantitative biology. The facility represents a major step in consolidating and strengthening the Division's and the Lab's efforts to deliver on the promises of synthetic biology. The new building will also enable program growth in biological and environmental research such as Genomics:GTL science, low-dose radiation, DNA repair, and functional genomics. The first scientists from the Synthetic Biology Design Team to occupy the new space include Jay Keasling, Carlos Bustamante, Adam Arkin and Daniel Fletcher. Together, they will comprise the Berkeley Center for Synthetic Biology, a joint program of the California Institute for Quantitative Biomedical Reasearch (QB3) and Berkeley Lab. Researchers hope the new location in the heart of the Bay Area bioscience hub will spawn collaborative research with institutions such as Bayer, Chiron, Xoma, Dynavax, and the University of California, San Francisco.

BERKELEY CENTER FOR SYNTHETIC BIOLOGY

About the Physical Biosciences Division and Berkeley Lab

The Physical Biosciences Division at Berkeley Lab is catalyzing the development of biology as a quantitative, predictive science. It builds on the extraordinary advances in temporal and spatial resolution and breakthroughs in modern computational and theoretical science to forge interdependent science at the leading edges of the biological and physical sciences. Lawrence Berkeley National Laboratory is a U.S Department of Energy facility, managed by the University of California. Berkeley Lab conducts unclassified research across a wide range of scientific disciplines with key efforts in fundamental studies of the universe; quantitative biology; nanoscience; new energy systems and environmental solutions; and the use of integrated computing as a tool for discovery.

What makes synthetic biology possible now?

- Advances in computing power
- Genomic sequencing
- Crystal structures of proteins
- High through-put technologies
- Biological databases
- Diverse biological sampling/collection

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